NASA SP-5957 (02)

TECHNOLOGY UTILIZATION

ANALYTICAL TECHNIQUES AND INSTRUMENTATION

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration and the Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This document is intended to furnish such technical information. The Compilation is presented in four sections. Section one introduces a variety of instruments and instrument systems found useful in analysis. Section two is involved with a selection of analyses in the study of matter. Section three deals with electrical and mechanical phenomena and their analysis in the physical rather than theoretical sense. Section four is devoted to three interesting analyses of the response of structures to various stimuli.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader Service Card included in this this Compilation;

Patent Statements reflect the latest information available at the final preparation of this Compilation. For those innovations on which NASA and AEC have decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

Patent information is included with several articles. For the reader's convenience, this information is repeated, along with more recently received information on other items, on the page following the last article in the text.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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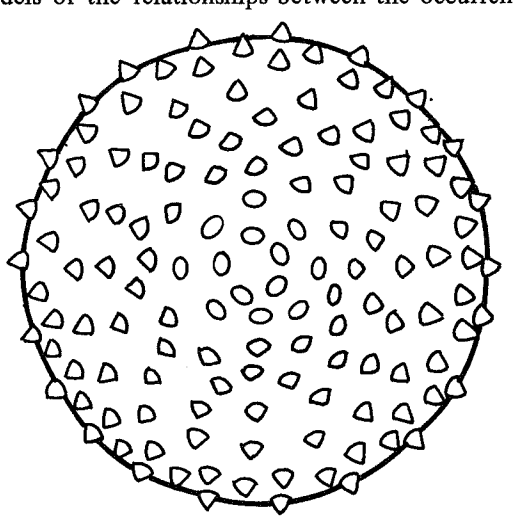
Contents

Section 1. Instrumentation for Analysis

JIMSPHERE ASSISTS ATMOSPHERIC TURBULENCE STUDIES

Since the inception of the FPS-16 Radar/Jimsphere (see figure) measurement system, it has been successfully applied to problems of aerospace vehicle design and operation where high-resolution measurements of wind shears are important. More recently, the system has been applied in attempts to actually detect turbulent motions in the free atmosphere, particularly those responsible for clear air turbulence as it affects aircraft design and operation. Data collected by the system offers a unique opportunity to investigate the relationship between atmospheric internal turbulence and fine-scale meteorological parameters. The purpose of the studies was to develop a data processing method for maximum information about atmospheric turbulence, including the vertical component, and application of the data processing method to a select cross section of data cases to demonstrate usefulness of the method. Individual case results were analyzed to provide improved conceptual and quantitative models of the relationships between the occurrence, intensity, and duration of clear air turbulence and predictable synoptic conditions. Case data were procured from a variety of locations throughout the country.



Jimsphere: Spiked Weather Balloon

The FPS-16 Radar/Jimsphere plot, mission critique information, and servoband strip charts are of value in real time planning of coordinated aircraft Jimsphere turbulence field programs, in assessing data quality before computer processing, in identifying regions of strong shears and turbulence, and in identifying excessive radar noise. The Jimsphere Turbulence Parameter Computation Program results are shown on special computer plots with superimposed pilot reports of turbulence. Plots of the high-resolution Jimsphere wind profiles show a strong relationship between certain mesoscale profile features and the occurrence of turbulence. Separation of the Jimsphere rise rate into mean and fluctuation parts appears to be useful for the purpose of identifying wave motions and turbulent layers.

The FPS-16 Radar/Jimsphere System provides processed data which when properly analyzed are extremely useful for the study of turbulence in the free atmosphere, especially the clear air turbulence which affects aircraft. The system is capable of actual detection of isolated layers of extraordinary turbulence when the system and data are used in an optimal manner.

Source: B. L. Neimann, J. R. Stinson, and
M. C. Day of
Meteorology Research Inc.
under contract to
Marshall Space Flight Center
(MFS-21702)

Circle 1 on Reader Service Card.

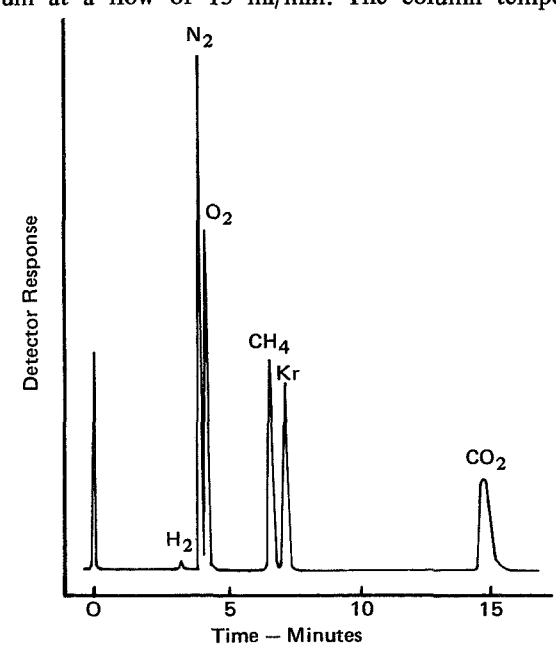
SIMPLE, GAS CHROMATOGRAPHIC SYSTEM FOR ANALYSIS OF MICROBIAL RESPIRATORY GASES

This is a simple, sensitive, gas chromatographic system for the determination of the microbial respiratory gases: hydrogen, nitrogen, oxygen, methane, and carbon dioxide. The system is designed to be small, light weight, and has low power consumption, so that it can be used in remote life-detection equipment for space experiments.

The system contains a room-temperature chromatograph consisting of a pair of capillary columns packed with Porapak Q that has been treated with phosphoric acid, a microbead thermistor detector, and a micro gas-sampling valve. The columns are wrapped snugly around a detector block and packed with a 15-cm cube of high-density Styrofoam.

Each of the columns is about 7 meters long and fabricated from stainless steel tubing, nominally 1/16-in. OD with 0.010-in. wall (1.6-mm OD, 0.25-mm wall). They are packed with 100/120-mesh Porapak Q which has been treated with enough methanolic-phosphoric acid solution to produce a 0.01% coating when dried in a rotary evaporator. The phosphoric acid treatment prevents carbon dioxide from being absorbed in trace amounts, and thus the symmetry of carbon dioxide peaks on the chromatograms is improved.

The chromatographic system is operated at 100 psig (800 kN/m^2 absolute) with high-purity helium at a flow of 15 ml/min. The column temperature is approximately 20° C, and only minor insulation is required to provide adequate temperature control; detector current is optimized at 11 mA.



The device has been used to measure gas composition changes in the head-space gas within a 6-ml metabolic chamber. Since multiple 100-μl gas samples used in the experiments represented a significant proportion of the chamber volume, krypton was added initially to the chamber as an internal standard; because krypton is not involved in metabolic activity, it is possible to make a correction for losses or pressure changes due to periodic withdrawal of samples.

In typical chromatograms obtained with this system, (see figure) resolution of nitrogen and oxygen is 98%; carbon monoxide and argon are not resolved from oxygen, but these gases generally are not found in the products of microbial respiration. Hydrogen gas can give a negative deflection when helium is used as the carrier, but the small amounts of hydrogen occurring in microbial respiration products do not give rise to this anomalous behavior.

Minimum detectable limits of the unit are of the order of 10^{-3} μmoles H_2, 10^{-4} μmoles CH_4, CO_2, and Kr, and 10^{-5} μmoles O_2 and N_2; these values are for a sample loop volume of 100 μl and a signal-to-noise ratio of 2 at a 25-μV noise level.

The dual column configuration was found to be insensitive to ambient pressure and temperature changes, and it produced chromatograms with lower noise level and greater baseline stability than a single column. Thus, the advantage to be gained by using single-column systems in spacecrafts to reduce weight, conserve carrier gas, and operate at lower power levels was outweighed by the superior performance of the dual-column, ambient temperature system.

Reference:

Carle, Glenn C.: Gas Chromatographic Determination of Hydrogen, Nitrogen, Oxygen, Methane, Krypton, and Carbon Dioxide at Room Temperature, Journal of Chromatographic Science, vol. 8, p. 550, 1970.

Source: Glenn C. Carle
Ames Research Center
(ARC-10403)

No further documentation is available.

SENSITIVE, CHEMILUMINESCENT OZONE DETECTORS

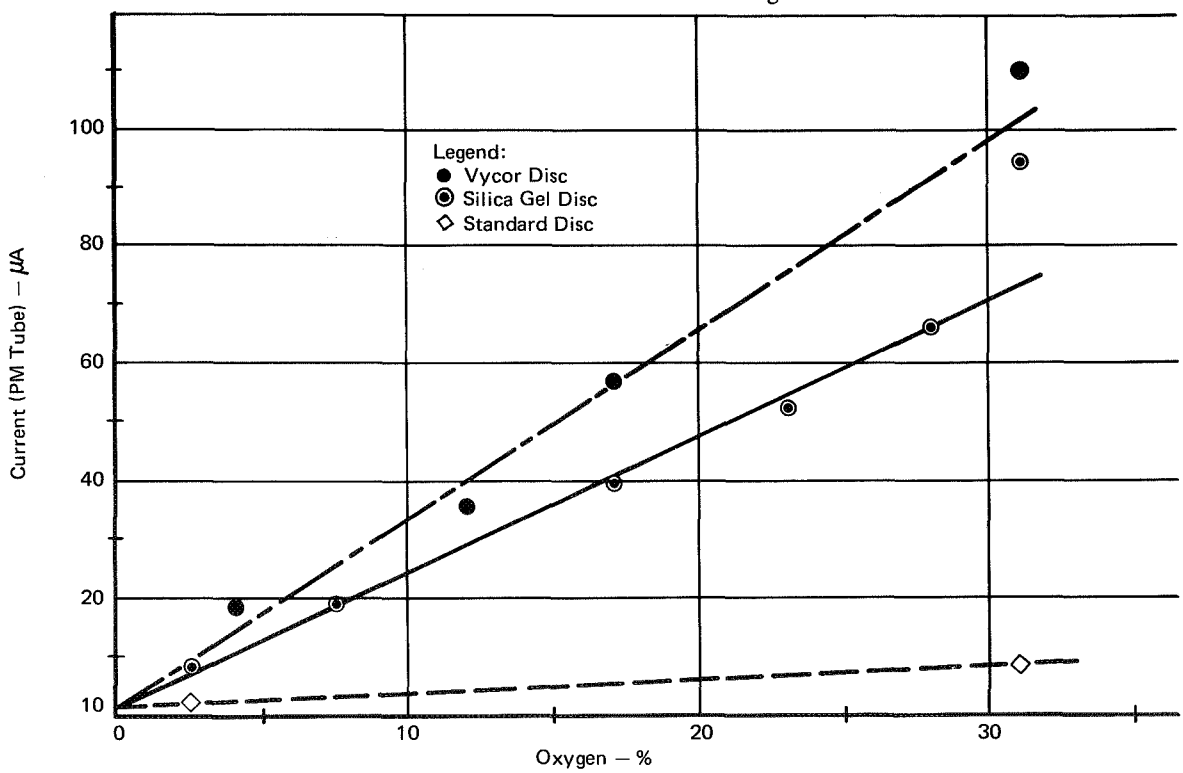
At altitudes below 40 km, ozone densities have been measured with reasonable accuracy. However, the measurement of ozone concentrations above the balloon altitudes of 40 km is still unreliable. Of particular interest is the altitude range from 40 to 70 km which requires a rocket-transported device that is sensitive to ozone concentrations from 10^{11} to 10^{9} molecules/cm^3, respectively.

Chemiluminescent disks using rhodamine-B are known to emit measurable light on exposure to ozone. By absorption of proper proportions of rhodamine-B and gallic acid into these disks, sensitivity to ozone is improved by a factor of 10 to 100.

The chemiluminescent disks are prepared in the following manner:

1. Dissolve a Vycor disk in a hot 10% sodium hydroxide solution until the disk reaches the desired thickness or until it becomes clear.
2. Wash the disk thoroughly in hot water until the disk gives a neutral reaction to pH indicator paper.
3. Dry the disk under ambient conditions until transparency returns.
4. Dip the disk in an acetone solution (2 mg gallic acid and 0.4 mg rhodamine-B per 1-ml solution) for 10 minutes.
5. Dry the disk in air and store in a dark dessicator until ready for use.

The figure shows the response of disks prepared by the various techniques measured with a photomultiplier tube. Under the conditions of these tests, the points for 30% oxygen were obtained with a flow of 130 cm^3/min and an ozone concentration of 4 ppm. Thus, there were 10^{16} molecules/min of ozone entering the reaction chamber.

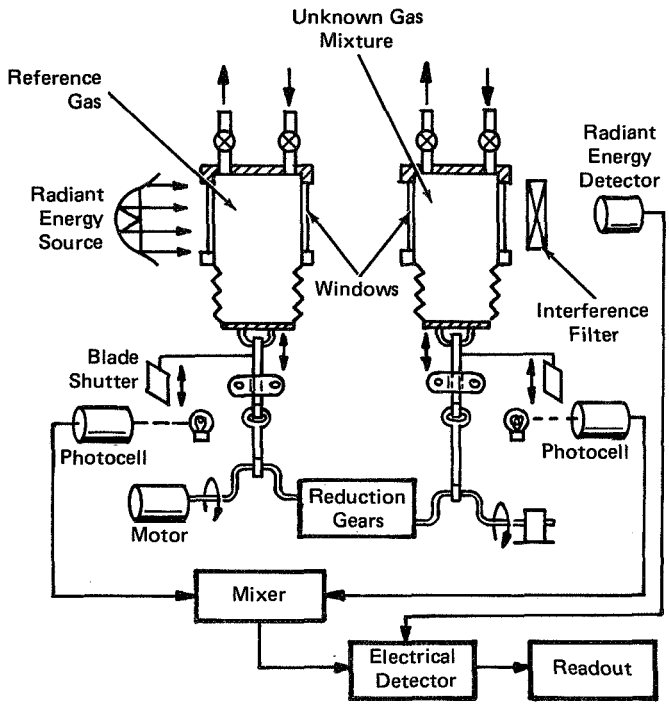


The results show that the gallic acid and rhodamine-B technique yields a substantially improved sensitivity. On a silica gel disk, the sensitivity is improved by a factor of 10 over that of the standard disk, while the Vycor disk shows an improvement of 100 times over that of the standard disk.

Source: J. G. Swanson of
Westinghouse Electric Corp.
under contract to
Goddard Space Flight Center
(GSC-11433)

Circle 2 on Reader Service Card.

NONDISPERSIVE INFRARED ANALYZER FOR SPECIFIC GASES IN COMPLEX MIXTURES



This innovation (see diagram) is a practical, nondispersive infrared analyzer for identifying and measuring particular diatomic or polyatomic gases in complex gas mixtures. Available nondispersive infrared gas analyzers are simple in structure and capable of high sensitivity; however, they are typically large and heavy and may be subject to serious gas cross-sensitivity effects. Additionally, the analyzers capable of good gas discrimination usually require the use of pneumatic detectors that have a low-frequency response and are often the source of zero drift and noise.

In this application, the densities of a reference gas and the unknown gas mixture are modulated in such a way that a mixing of absorption effects on light energy, passing through the gases to a photodetector, produces a signal component that is related to the absorption caused by the reference-gas component in the unknown gas mixture.

As indicated by the diagram, the unknown gas mixture and the reference gas (that is, the component being sought) are contained in windowed cells, and the gas densities are caused to vary periodically by mechanically operated bellows. Radiation from a blackbody source is directed through both gas cells and the interference filter to a photodetector. Certain wavelengths of the radiation are absorbed in each gas; hence, the intensity of the radiation reaching the photodetector is an oscillating function of the absorption characteristics of the reference gas and the unknown gas mixture.

The density of the reference gas is caused to vary at a frequency f_1 by the compressor bellows, and the density of the unknown gas mixture is varied at a second frequency f_2.

A blade shutter for the reference gas is interposed periodically between a lamp and a photocell; the photocell generates an electrical signal which alternates at the frequency f_1, and another blade shutter gives rise to a signal for the unknown gas mixture at a frequency f_2. The two signals are then beat together in the mixer to produce a difference signal at a fre-

quency ($f_1 - f_2$) which is fed to the electrical detector, usually a phase-lock amplifier or similar device which is capable of selecting from one input signal a particular signal component corresponding to another input signal, in this case, the output of the radiant energy photodetector.

There will be signal mixing in the radiation seen by the photodetector, since the densities of the reference and unknown gases are varied at the frequencies f_1 and f_2, respectively; and the absorption process is exponential and, hence, inherently nonlinear. Accordingly, the electrical signal generated by the photodetector will have frequencies f_1, f_2, $(f_1 + f_2)$, $(f_1 - f_2)$, etc. Since the signal component corresponding to the particular gas to be analyzed in the unknown mixture is $(f_1 - f_2)$, the output of the electrical detector will be the $(f_1 - f_2)$ component in the signal from the radiant energy photodetector. The amplitude of this signal component is directly proportional to the concentration of the specific gas in the unknown. This output signal is fed into a readout system for display or recording.

The apparatus and technique permit the arbitrary and convenient selection of a particular gas to be analyzed and minimizes spurious signals introduced by other gases in the mixture being analyzed.

In the prototype model, the mechanical bellows was replaced with a speaker driven by a suitable oscillator, and driving a Helmholtz resonator. The signal obtained from the blade shutter was also replaced by a signal derived from the power oscillator that drives the speaker. Dynamic pressure amplitudes of 10% of the quiescent pressure were obtained.

The unit was also modified to include three reference gases and to introduce one of three bandpass filters in the optical path by a panel-switch controlled filter wheel. The introduction of a particular filter rejected portions of the spectrum occupied by the absorption spectrum of two of the three gases, thereby allowing measurement of the concentration of the third gas in the unknown mixture.

For a two-centimeter path length in the unknown chamber, the portotype measured part-per-million concentrations for carbon monoxide, carbon dioxide, and methane.

Source: John Dimeff, Ralph W. Donaldson, Jr., William D. Gunter, and Gordon J. Deboo of Ames Research Center
(ARC-10308)

Circle 3 on Reader Service Card.

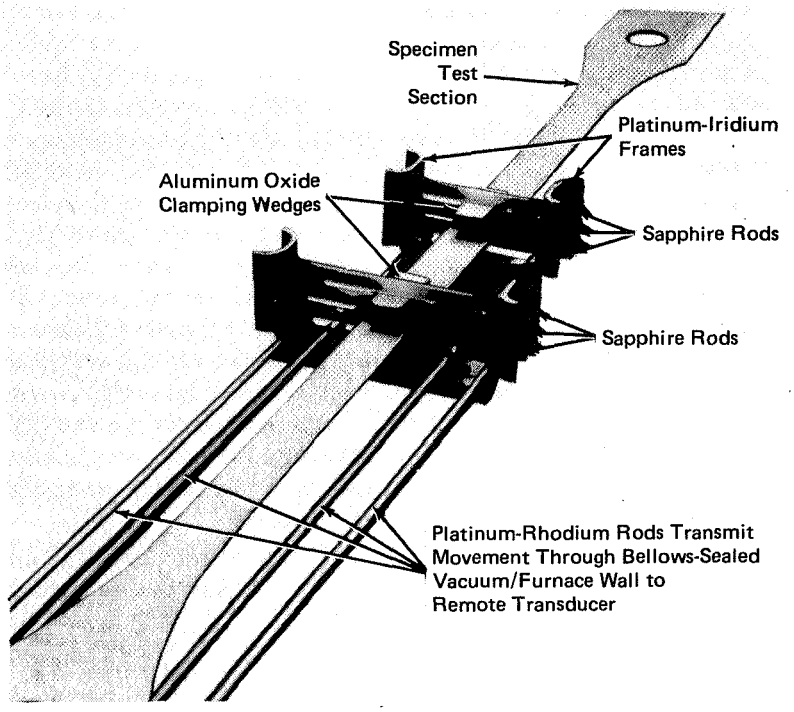
COMPUTER SYSTEM SIMULATION AND ANALYSIS

A simulation model consisting of two major elements has been developed to study different computer system configurations. The simulator compares the relative merits of two or more configurations by simulating the systems when processing a given workload. The two major elements contained within the system are the system configuration being simulated and the workload being processed by the simulated system. The model simulates the number and speed of the system central processors, the number of input/output data channels, and the speeds of the input/output peripherals. The model also provides for simulation of configurations with dedicated processors for nonuser or system processing. The workload processed by the simulated system is described in terms of the number of equivalent adds performed during computation and the number of data bits transferred while performing input/output. The model is written in the GPSS simulation language and uses the statistics-gathering features of that language to measure the performance of a configuration as it processes a particular workload.

Source: T. Williams and J. E. Weatherbee of Computer Sciences Corp.
under contract to
Marshall Space Flight Center
(MFS-22045)

Circle 4 on Reader Service Card.

STRAIN-MEASURING EXTENSOMETER FOR USE AT TEMPERATURES TO 1644 K



This innovation makes use of platinum, iridium, and sapphire materials to withstand test temperatures to 1644 K (2500° F). The instrument permits load vs. strain characteristics of materials to be determined at these temperatures in a thermal/vacuum or thermal/controlled-atmosphere furnace. Previous instruments used point contact clamps of tantalum which frequently damaged coatings used to protect the test specimens. In this device, sapphire rod, which is the only material in contact with the specimen, does not react with test material protective coatings.

As shown in the photograph, the grip of the extensometer to the test specimen is accomplished with sapphire rods, which also define the gauge length. An aluminum wedge inserted between the first and second sapphire rods exerts clamping pressure on the specimen, which is inserted between the second and third sapphire rods. Due to the high-temperature properties of the sapphire rods, this pressure is maintained at 1644 K (2500° F).

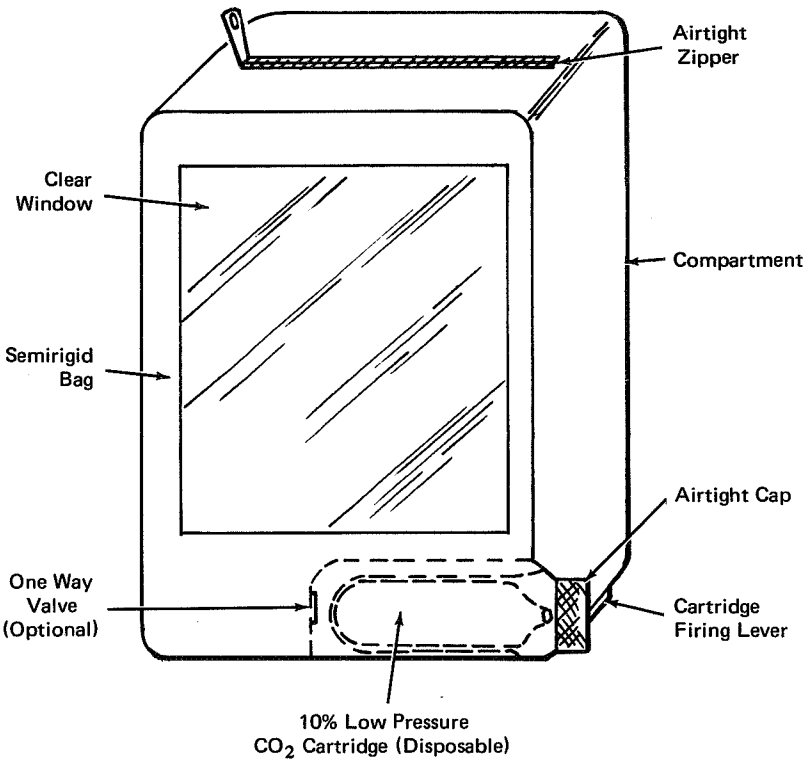
This method of extensometer attachment minimizes damage to protective coatings and eliminates single-point contact stress risers which have caused premature specimen failures.

The platinum/rhodium tubing attached to the extensometer heads transmits strain movement to a microformer transducer. The transducer is located out of the heated test section of the furnace, as it is operative to a maximum temperature of 533 K (500° F). The extensometer, when used in conjunction with the stress/strain recorder of a universal type tensile test machine, will provide an autographically recorded plot of load vs. specimen deformation.

Source: W. G. Boyd of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17830)

No further documentation is available.

REUSABLE ANAEROBIC SYSTEM FOR MICROBIOLOGICAL STUDIES: A CONCEPT



A compact, reusable, inexpensive chamber system has been designed for use in microbiological studies of anaerobic organisms that require incubation in a 10% partial CO_2 atmosphere for cultivation. A number of bacteria pathogenic to man, particularly gonococcus, meningococcus, and brucella, require an atmosphere of higher-than-normal CO_2 content.

The reusable anaerobic system (shown in the figure) is composed of a simple, semirigid incubation chamber (Teflon-lined Beta cloth or similar material) with a clear Teflon window, airtight zipper, and internal compartments for petri dishes or microbiological plates. A small, low-pressure CO_2 cartridge, similar to cartridges employed for CO_2 guns, supplies the carbon dioxide for the chamber atmosphere. The CO_2 delivery system is composed of a cartridge-firing lever mounted in an airtight cap, a delivery tube, and an optional one-way valve.

The system, because of its low cost and simplicity, should be of interest to schools, medical laboratories, and the manufacturers of biological and pharmaceutical supplies.

This invention is in the conceptual stage only. At the time of this publication, no model or prototype exists.

Source: C. Murawczyk of
Martin Marietta Corp.
under contract to
Johnson Space Center
(MSC-13920)

No further documentation is available.

MASS SPECTROMETER, ATMOSPHERIC SENSOR SYSTEM

A portable mass spectrometer simultaneously monitors the total contaminants of an atmospheric environment, and the specific amount of each atmospheric gas. The atmospheric gases include hydrogen, oxygen, nitrogen, water vapor, and carbon dioxide.

The mass spectrometer's indicating ranges and accuracies are as follows:

Gas	Range (%)	Accuracy (% Full Scale)
Hydrogen	0-1	±10
Oxygen	0-100	±2
Nitrogen	0-40	±2
Water Vapor	0-10	±5
Carbon Dioxide	0-7	±3

Total Contaminants – For information and indication only

Total System Pressure is 330 Torr

The Spectrometer Atmospheric Sensor System is a flight-qualified device. The spectrometer operates on 28 volts dc, having its own internal power supply. The approximate dimensions are 25.4 cm (10 inches) long by 17.8 cm (7 inches) in diameter. The small size of the spectrometer makes it suitable for monitoring hazardous environments such as underground mines, undersea laboratories, and chemical plants.

Source: Perkin-Elmer Corp.
under contract to
Johnson Space Center
(MSC-13898)

Circle 5 on Reader Service Card.

HIGH-TEMPERATURE, TENSILE-TEST EXTENSOMETER SYSTEM

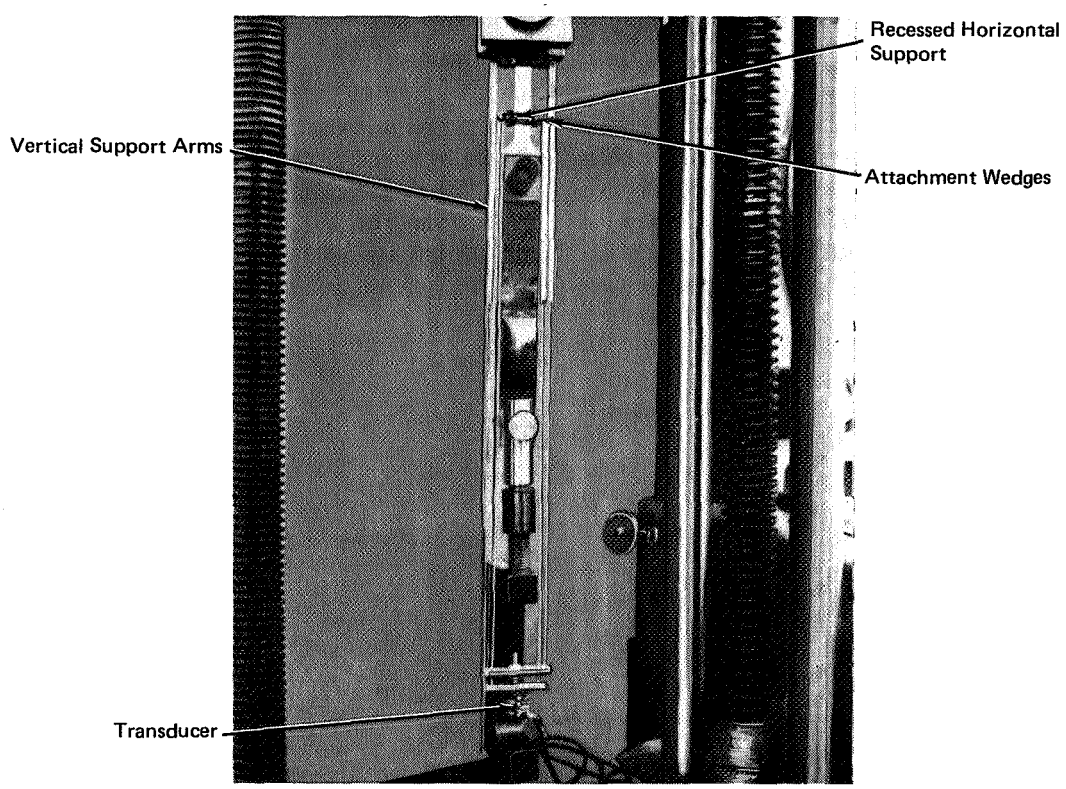


Figure 1. High-Temperature (2000-2500° F), Tensile-Test Extensometer System

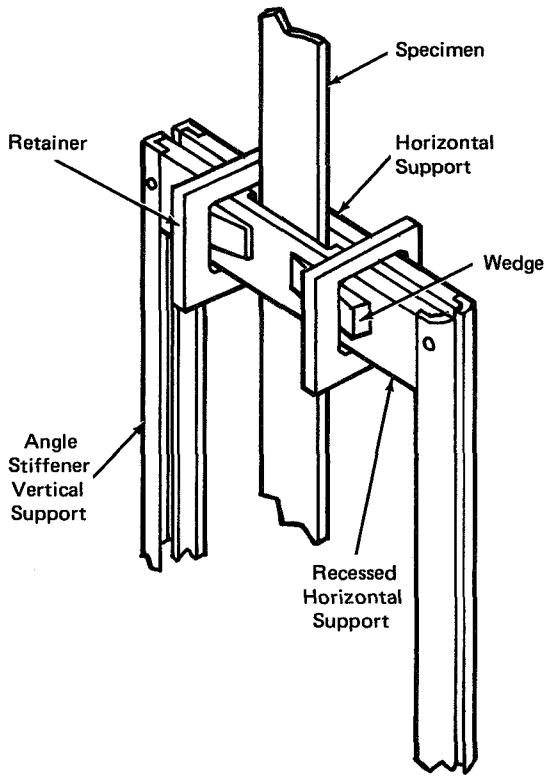


Figure 2. Horizontal Support

This innovation (see Figure 1) is a high temperature, tensile test, extensometer system that features lightweight and inexpensive fabrication. The system is specifically intended for tensile-and-creep property evaluation of high temperature metal and composite materials at test temperatures from 1366 to 1644 K (2000° to 2500° F).

Previous methods incorporated vertical support elements which were attached transversely to the horizontal elements holding the test specimen. Thermal expansion introduced appreciable movement of the vertical support elements due to the flexibility of these arms. Large variations of movement in one or the other vertical support element resulted in rotation of the extensometer and subsequent interference with the performance of the transducer and core.

Recessing the horizontal support member (Figure 2) and stiffening the system by using thin angle members provides a lightweight, inexpensive extensometer system which can be made of readily available sheet material with minimal machining.

Source: F. A. Rutkosky of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17712)

Circle 6 on Reader Service Card.

SAMPLE HOLDER FOR MÖSSBAUER SPECTROSCOPY

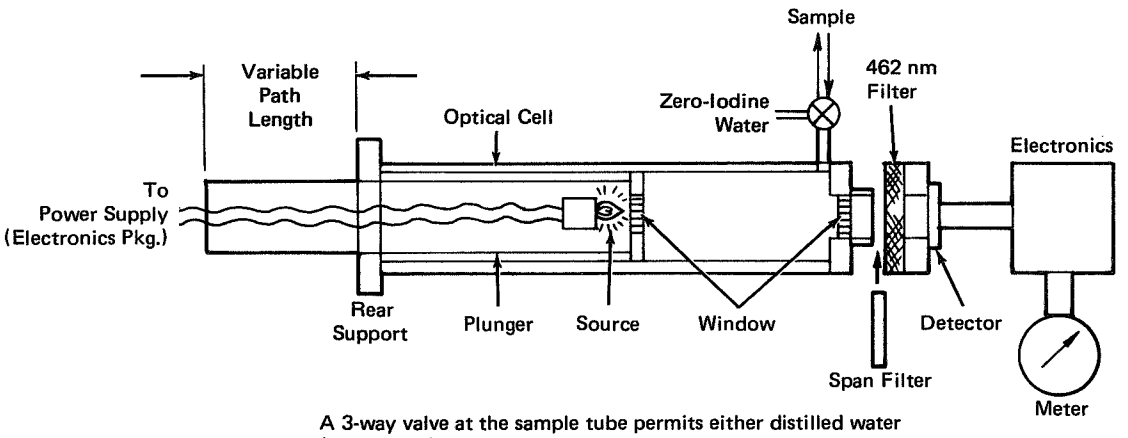
A high-purity beryllium chamber provides a vacuum environment for conventional Mössbauer spectroscopy studies of lunar samples. It can be handled in air and permits conventional transmission Mössbauer experiments to be performed at variable temperatures.

The chamber has several advantages over prior methods. It allows convenient transmission geometry for Mössbauer spectroscopy; it provides a uniform sample of desired thickness; and it allows easy handling and mounting into dewars for low-temperature experiments.

Source: R. W. Grant, A. C. Jones
and K. G. Rasmussen of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17444)

Circle 7 on Reader Service Card.

IODINE MONITOR: AN ANALYSIS TOOL



A 3-way valve at the sample tube permits either distilled water (zero iodine) or sample water to enter or leave the cell

Figure 1. Block Diagram Of Iodine Colorimeter

Iodine is to be added to water as a bacteriocidal agent to provide drinking water of adequate quality for long-term space flights. Because of the evanescent nature of iodine, it will be necessary to monitor its concentration by accurate and reliable means in order to insure constant quality. However, the spacecraft environment creates several problems which must be resolved to effect this measurement: zero gravity prohibits any gravity-dependent technique; complicated procedures are incompatible with human engineering procedures; and multiple reagents create storage problems.

The developmental work was motivated by the need for a simple, effective measuring technique for determining levels of aqueous iodine concentration. Several methods are available for the quantitative determination of iodine; but electrochemical techniques, titration procedures, or colorimetric methods requiring reagents are unsatisfactory for the spacecraft application.

Having determined by spectrophotometric experiments that aqueous iodine in low-parts-per-million concentration can be measured directly, the objective was to evolve a prototype instrument embodying the

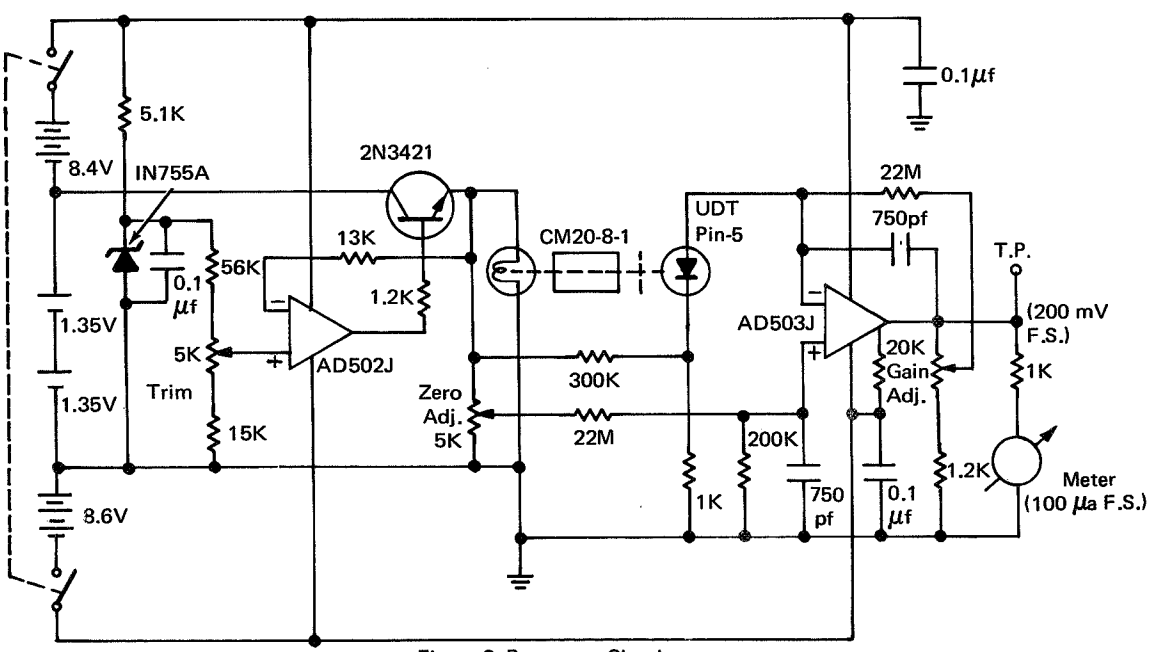


Figure 2. Prototype Circuit

desired characteristics and demonstrating the feasibility of the direct spectrophotometric concept.

The instrument, developed for measuring 0-10 ppm I_2, is a specific wavelength colorimeter. The feasibility of a direct spectrophotometric measurement was established by scanning highly diluted, aqueous iodine solutions in a Beckman DK Spectrophotometer. It was found that even in very dilute solutions iodine shows a useful absorption peak at 462 nm. Two other peaks representing tri-iodine appear at 352 and 288 nm in highly concentrated solution or if potassium iodide is also present. Since I_2 is considered the most bacteriostatic form of this element, the colorimeter is optically designed to measure I_2 only.

Based on successful breadboard studies, the prototype instrument is a novel assembly of mechanical, optical, and electrical systems. The essential components are illustrated in Figure 1. Special attention was given to the electronics. A regulator circuit maintains constant voltage for the lamp throughout useful battery life. An operational amplifier amplifies the differential detector signal to operate the meter. A PIN/photoconductive junction-type cell utilizing Schottky barrier technology replaces a cadmium sulfide cell that was originally used. For this application the detector, having no memory effects, gives excellent performance. The circuit is shown in Figure 2.

With iodine-free water in the sample cell, the instrument is calibrated by setting the meter to zero, then inserting a span filter into the optical path, and adjusting the gain to an indicated meter reading. "Zero-iodine" samples and sample iodine solutions are pumped in and out of the sample cell by a piston. The Kel-F piston band carries the lamp source. A small valve connects the sample cell to either "zero-iodine" or "sample" input ports. "Zero-iodine" water is supplied from an attached water bag. In addition to the zero, span, and filter controls, an "empty-fill" knob on the instrument operates a rack and pinion gear system which traverses the sample cell piston. The colorimeter can be hand-held with all controls readily accessible.

The iodine colorimeter will measure aqueous iodine reliably over a 0- to 10-ppm I_2 range with an accuracy of 0.5 ppm. Although designed to measure iodine in pure water, the instrument will also determine iodine in solution with iodides. The effect of several, possible interfering compounds is negligible. No reagents are required; the method is simple and direct, requiring minimal effort on the part of the operator.

After proving the feasibility of a direct photometric technique for measuring aqueous iodine, primary effort was directed toward the practical development of an optical, mechanical, and electronic assembly. The prototype which was the objective of this project has been analyzed, and the instrument configuration points out areas where further work would result in significantly decreased overall dimensions – perhaps as much as a 50-percent reduction in size.

An evaluative consideration of the iodine colorimeter suggests that, in addition to its specified application to Skylab, it can be used as a field-model colorimeter, fitted as required with other applicable filters in place of the 462-nm filter for iodine. It can also be used as a nephelometer in water analysis.

Source: C. Brawner of
Beckman Instruments, Inc.
under contract to
Johnson Space Center
(MSC-14081)

No further documentation is available.

Section 2. Analysis of Matter

DETERMINATION OF GRAPHITE/POLYIMIDE CONSTITUENT FRACTIONS BY PARAMETRIC GRAPHIC METHODS

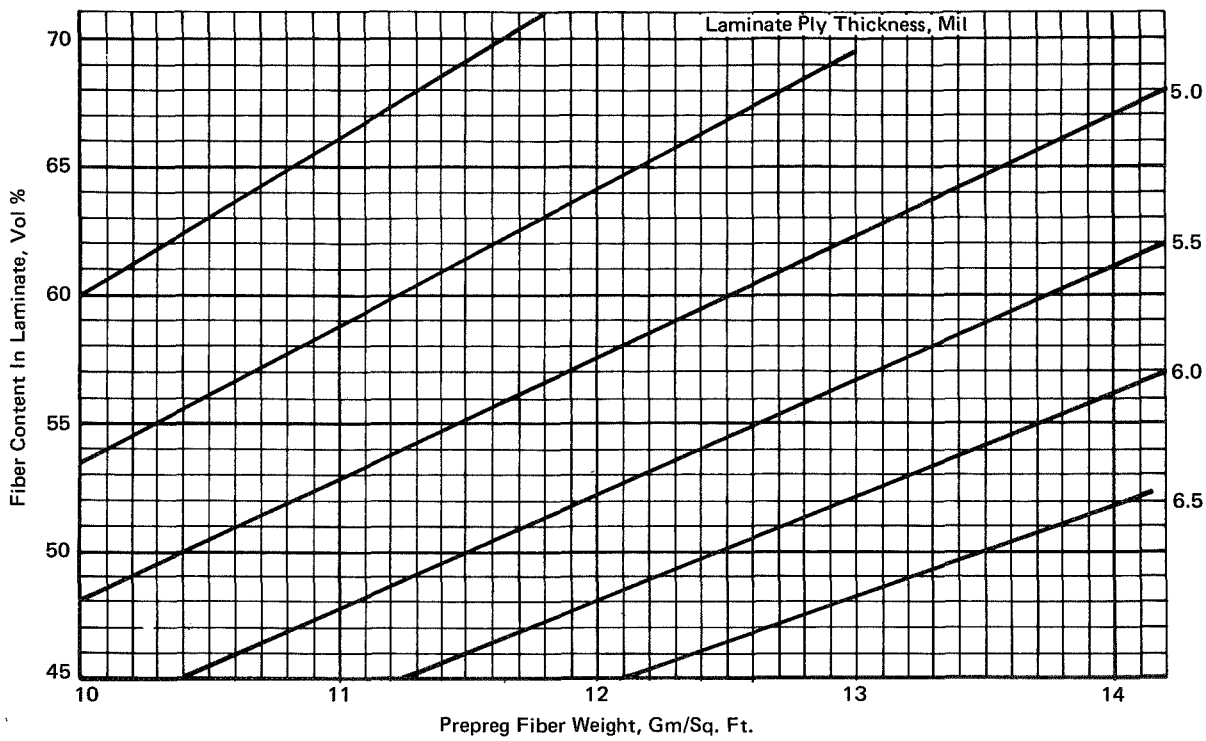


Figure 1. Fiber Weight vs. Fiber Content in Volume %.

Present methods of determining the constituent fractions of graphite/polyimide composites are time-consuming, expensive, and, up to now, somewhat suspect as to accuracy and reproducibility. Fiber volume percentage of laminates has usually been obtained by acid digestion analytical methods.

Parametric graphs have been developed from simple measurements and give reasonably accurate estimations of constituent fractions for two commercially available materials.

The fiber content of the cured laminate in volume percent can be read off from the information provided in Figure 1. The average prepreg fiber weight per ply per unit area is known from determinations on the prepreg and is assumed to remain constant in the laminate. The average ply thickness can be simply determined by micrometer measurement, dividing the laminate thickness of plies used. The curves relating the fiber volume percentage to the prepreg unit weight for the various ply thicknesses have been derived for the Modmor II density, ρ_f = 0.0635 lb/in.^{3}, from the following simple relation:

$$V_f = \frac{W_2}{454 \times 144 \times \rho_f \times t_2} \times 100$$

where:

V_f = Volume percent of fiber in laminate
W_2 = Weight of fiber in prepreg, gm/ft^2
ρ_f = Fiber densitym lb/in.^{3}
t_2 = Ply thickness of cured laminate

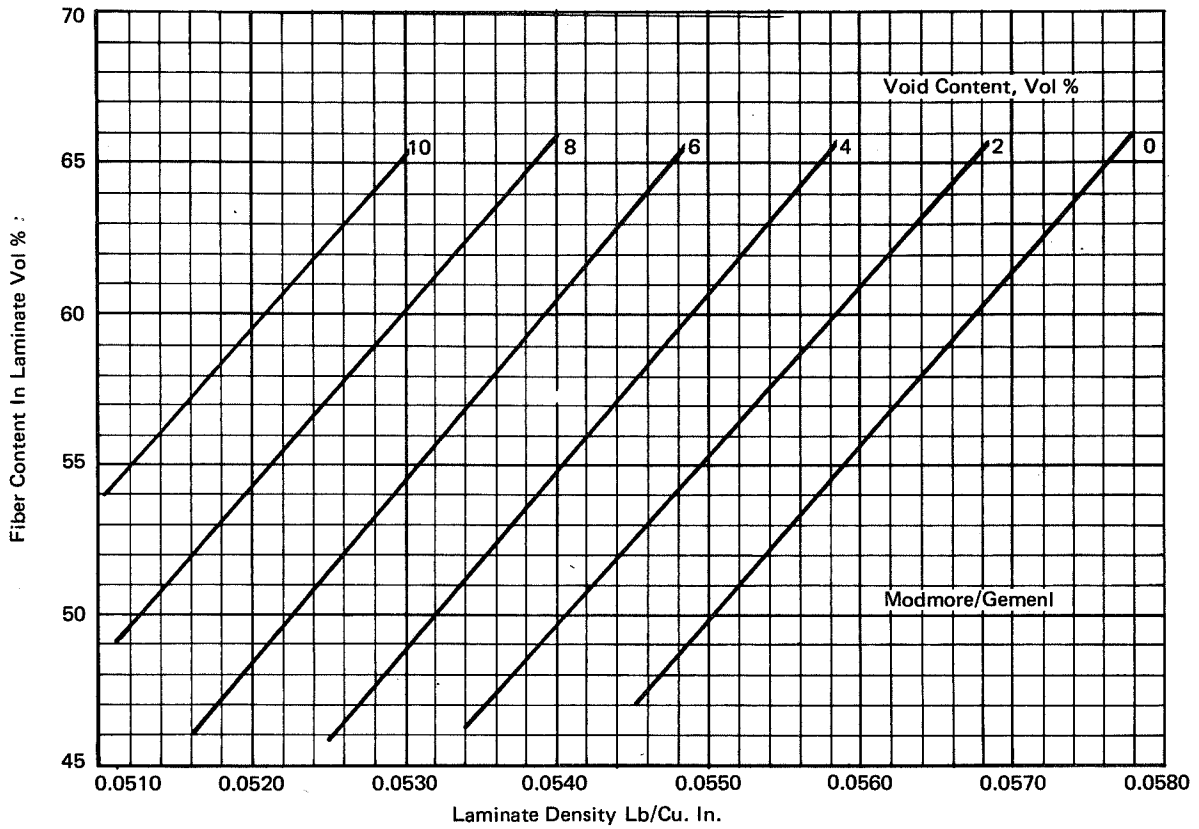


Figure 2. Laminate Density vs. Fiber Volume % for Constant Void Content

Figure 2 permits estimation of the void content in volume percent. The fiber content, known from Figure 1, is plotted against laminate density (a simple determination) for a series of constant void contents from the relation:

$$\rho l = \frac{V_f \rho_f + V_r \rho_r}{100}$$

The constituent fractions are related by

$$V_r = 100 - V_f - V_v$$

Symbols used are:

V = Constituent Content, Volume Percent
ρ = Density, lb/in.^{3}

and subscripts

l = Laminate
f = Fiber
r = Resin, 0.0466 lb/in.^{3}
v = Voids

It is expected that information derived in the fashion described will be sufficiently accurate for wing box beam program purposes, provided uniformity of the prepreg material is within specified boundaries.

Source: M. A. Nadler of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24039)

Circle 8 on Reader Service Card.

STARCH-IODIDE SOLUTION AS ANALYTIC REAGENT

There are a number of ways of determining oxidizing agents in aqueous solution at low concentrations. Titration of the solution with a reducing agent, using some suitable means of end-point detection, may be used for moderate concentrations of oxidizing agent. For lower concentrations, colorimetric methods are used in which the oxidizing agent produces a color in solution which has an intensity proportional to the oxidizing agent concentration. A large variety of chemical analyses utilize one or the other of these procedures.

One of the most convenient of end-point indicators (for titration or colorimetric methods) is starch-iodide solution, which is prepared by dispersing a small amount of starch in water containing a soluble iodide such as potassium iodide. The resulting preparation has a number of disadvantages: in particular, lack of stability, variable response, and high and variable turbidity

The starch-iodide solution of this invention (called improved, cadmium iodide-linear starch reagent) has a shelf life in excess of a year. There is very little increase of turbidity or decrease in response with age; therefore, standardizations against unknown concentrations of oxidizing agents need by done only infrequently. The very low turbidity of this invention, as compared with most starch-iodide reagents, is a further advantage since it allows unambiguous detection and accurate determination of very low concentrations of oxidizing agents.

The improved, cadmium iodide-linear starch reagent is prepared as follows:

Dissolve 11.0 ± 0.2 grams of cadmium iodide, reagent grade, in 400 ± 50 milliliters (ml) of distilled or deionized water and boil gently for 15 minutes to expel any iodine. Dilute to 800 ± 50 ml, bring to a boil again, and slowly add 15 ± 0.2 grams of linear, amylose starch fraction to the gently boiling solution while stirring. Continue boiling and stirring for 10 ± 3 minutes. Filter with suction through an 18.5-centimeter Buchner funnel, using Whatman No. 50 filter paper. To increase filtration rate, change the filter paper when filtration rate slows. Filter a second time through an 11-centimeter Buckner funnel, using Whatman No. 50 filter paper. Dilute the filtrate to 4.0 ± 0.1 liters and store in a cool, dark place.

Source; C. A. Smith of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-22070)

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TECHNIQUE FOR THE DETECTION OF IMPURITIES IN SMALL QUANTITIES OF WATER

Analytical precipitation chemistry and filtration technology have been combined to facilitate the detection and identification of impurities in small quantities of water. Approximately one milliliter of water is placed on reagent-impregnated filter paper tape. Different impurities react with specific reagents to produce a characteristic insoluble precipitate. To concentrate the precipitated impurity in a limited area, the water is quickly drawn through the filter tape by a vacuum line positioned beneath the reaction site.

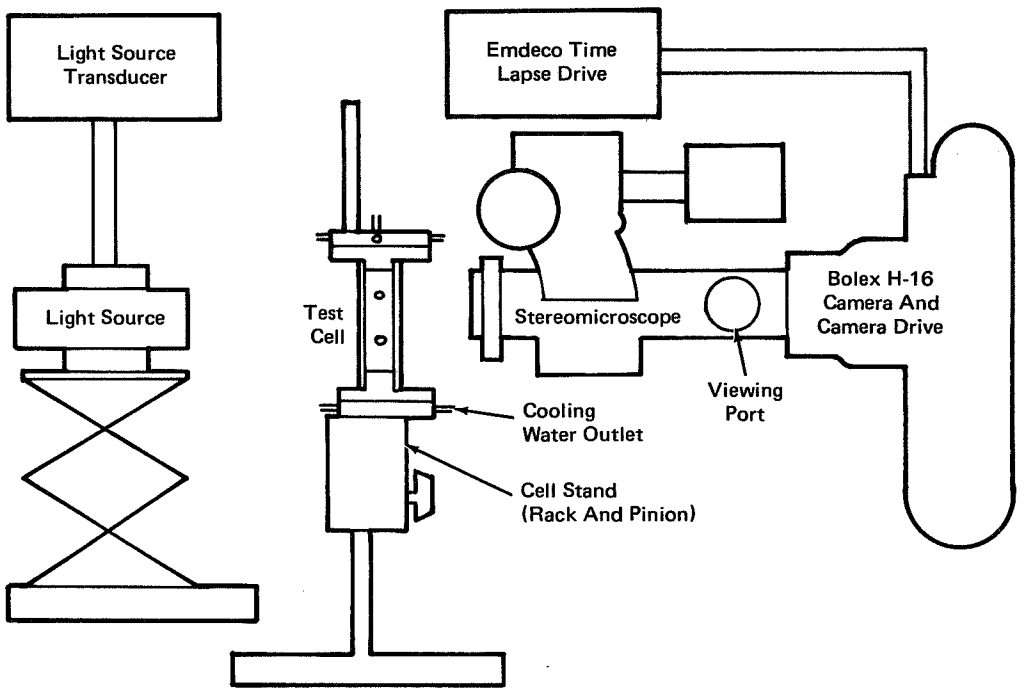
Tapes impregnated with p-dimethylaminobenzyldiene rodamine, lead chloride, calcium hydroxide, dithizone, and $\alpha\alpha'$-dipyridyl have been successfully used for the detection of silver, hydrogen sulfide and chromium, manganese, lead, and iron, respectively.

The technique appears applicable to numerous areas where microquantities are examined. It could be of obvious value in air pollution, toxicological, or microbiological studies.

Source: H. deSchmertzing of
Melpar, Inc.
under contract to
Johnson Space Center
(MSC-11013)

No further documentation is available.

A MICROSCOPIC AND THERMAL STUDY OF THE SOLIDIFICATION OF HEXADECANE



Time Lapse Microphotography Equipment Diagram

Recent interest in the n-paraffins as potential candidates for use in phase-change, thermal control systems has inspired an investigation aimed at determining their solidification processes both on earth and in space. The investigation was performed with two objectives in mind:

(1) To develop an improved microphotography system for observing the phase-change process.
(2) To perform meaningful studies on the crystallization dynamics of the solidification of the n-paraffins (hexadecane and octadecane were used).

The microphotography system (see figure) was developed by modification of existing equipment. Improved features resulting from the modification were a variable magnification capability and a test-cell stand that features a micrometer-controlled, rack and pinion drive that permits minute movement of the test cell while studying individual crystal growth rate. The improved system was used to study the solidification process of the two n-paraffins under a variety of experimental conditions. Parameters investigated were average interfacial velocity, crystal peak height, individual crystal growth rates, crystal morphology, and temperature response of the test cell.

Source: J. O. Golden and F. J. Stermole of
Colorado School of Mines
under contract to
Marshall Space Flight Center
(MFS-20961)

Circle 10 on Reader Service Card.

PELLETIZING OF ORGANIC LIQUIDS FOR INFRARED ANALYSIS

A composite method was required for quantitative and qualitative analysis of contaminants accumulated in space environment simulation chambers. This technique was developed to accomplish the measurement, which permits identification of contaminants and determination of the quantities present, by concentrating the contaminants collected over a large area into a small area in a medium (potassium bromide) that does not have interfering absorption in the infrared portion of the spectrum. Prior to this development, analysis of liquids was performed by separate sample-handling techniques for qualitative and quantitative determinations, both involving infrared spectrophotometry. The improvement is more sensitive than either of the previous techniques (absorbance of solution and transmittance of residue on a transmitting plate) and permits quantitative analysis via infrared in the region 6 to 15 microns where the solvent, carbon tetrachloride, absorbs and does not allow good measurements. Contaminant analysis can be achieved by other means such as gas chromatography and mass spectrometry; however, these techniques yield too much data, i.e., each constituent of a polymeric series and of a hydrocarbon mixture, whereas only total hydrocarbons and total polymers of given types is the information desired and directly yielded by infrared analysis.

The technique is simply an extension of the potassium bromide pelletizing technique to include liquids of low volatility. Potassium bromide pelletizing has long been used for infrared analysis of solid materials and has been primarily a qualitative tool. The liquid is introduced to dry KBr powder by mixing the powder with 0.5 ml of a carbon tetrachloride (CCl_4) solution of the liquid, by grinding in an agate mortar with an agate pestle. 205 milligrams of KBr powder should be used for a 1/2-inch diameter pellet-making die. The KBr liquid mixture is then transferred to the die, which is evacuated at a pressure of less than 2 torr for a period of one minute (to remove air, moisture, and solid which would otherwise shatter the pellet upon decompression). The mixture is then pressed into a pellet under vacuum, using pressures prescribed for the particular die being used. The pellet is then removed from the die and its transmittance or absorbency spectrum is measured with an infrared spectrophotometer. The amount of liquid measured should not exceed 10 milligrams. To achieve quantitative analysis, the technique should be calibrated by the individual laboratory employing it for the substances commonly encountered.

This technique permits analysis of liquids by infrared spectrum of salt pellets. The accomplishment is actually demonstration of the fact that liquids can be handled in pellets as are solids. The technique permits quantitative analysis without interference from solvent bands and increases sensitivity, since the sample can be concentrated into a small pellet. The accuracy of the quantitative analysis is not very good, because calibration curves are usually nonlinear with concentration. But the fact that quantitative and qualitative analyses can be performed for families of compounds in a single measurement makes the technique valuable, especially in contamination measurements.

Source: C. M. Wolff of
Brown & Root-Northrop
under contract to
Johnson Space Center
(MSC-14137)

No further documentation is available.

SIMPLIFIED PROCEDURE FOR EMISSION SPECTROCHEMICAL ANALYSIS

A simplified single procedure for rapid, quantitative spectrochemical analysis can handle virtually any metallic sample, regardless of size or composition.

Emission spectroscopy, a well-established technique in chemical analysis, is especially suited to high-volume routine analyses of a single sample type; i.e., samples of the same physical form and of relatively narrow composition ranges. The technique becomes progressively more limited in applications with samples of varying sizes, compositions, and physical structures, and ultimately becomes impractical for the quantitative analysis of few-of-a-kind samples. The major limitation in the spectrochemical analysis of nonroutine samples is the necessity to develop

detailed procedures (such as sample preparation, spectra excitation, quantitative calibrations, and data reduction) for each different sample type. The time and cost required to quantify the procedures effectively cancels the potential advantages of the spectrochemical technique for analyzing only a few samples.

In the new technique, a relatively simple procedure involving dissolution of samples is used to prepare all samples for analysis, and all samples are analyzed using a single set of experimental conditions. In many cases, no comparison standards are necessary because the procedure effectively reduces so-called matrix effects. (When standards are necessary, they can be easily prepared by blending stock solutions of the various metal constituents.) This single procedure can be used to analyze a wide variety of materials and compositions, without compromising analysis accuracy or requiring numerous separate and more complex procedures.

Because the identical procedural steps are used for all dissolved samples, the procedure has been automated to achieve a high sample rate. With the use of this automated spectrometer, the per-sample analysis time is about four minutes after sample dissolution. Normally, triplicate excitations are made of each sample solution. The system will perform automatic excitations of a series of samples and will record the analysis data from a maximum of 22 metal constituents. Computer data processing is used to compute either absolute microgram amounts of metals or percentage compositions. The computer program also provides automatic correction of spectral line interferences.

The instrument system and procedures have been successfully applied to the quantitative analysis of a wide variety of sample types including: high-temperature and refractory alloys, extracted phases from these alloys, oxide vapor deposits on platinum and glass substrates, 10-microgram microspheres of condensed metal aerosols, metal constituents concentrated at fracture surfaces of alloys, industrial hygiene and pollution samples, and trace metals in biological samples.

This development was made possible by several key refinements in the use of a direct current arc which is used to excite the atomic spectra. The elimination of arc wander and the control of light intensity or arc current, together with the operation of the arc under closely controlled conditions in argon atmospheres, resulted in the required detection limits and precision for the successful application of this procedure.

Control of the arc current light intensity is described in NASA Tech Brief 67-10404, Control Apparatus for Spectral Energy Source, which may be obtained from the Technology Utilization Division. NASA, Code KT, Washington, D.C. 20546.

Reference:

NASA-TN-D-5532 (N70-10367) Quantitative Direct Current Arc Analysis of Random Compositions of Microgram Residues in Silver Chloride Common-Matrix,

Which may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $1.45)

Source: W. A. Gordon
Lewis Research Center
(LEW-10985)

Section 3.

Analysis of Electrical and Mechanical Phenomena

CRITICAL-SPEED ANALYSIS OF ROTORS

Many theoretical studies of rotor critical speeds assume firm foundations for simplicity in analysis. Models that treat foundation flexibility, however, are more representative of aircraft and spacecraft installations. A flexible-foundation model has the added complication of two more variables than a firm-foundation model. There is little information available on flexible-foundation, critical-speed analysis.

A general frequency equation has been developed for both forward and backward precession of rigid rotors in undamped bearings on flexible foundations. One set of two solutions comprises the bouncing-mode natural frequency. This frequency is a function of foundation-to-rotor mass and spring-constant ratios, but is independent of rotor speed and moments of inertia. Another set, the conical mode, which is a function of rotor speed and moments of inertia, contains four solutions.

Maps have been developed for a wide range of these variables. The spring-constant ratio is varied to represent the entire range from zero (floating foundation) to infinity (firm foundation). The moments of inertia are varied to represent configurations ranging from pencil shapes to disks. Besides locating major critical speeds, the maps locate nonsynchronous critical speeds that may result from bearing defects. Therefore, for a given rotor, the maps display the succession of critical speeds encountered during startup or shutdown.

Plots may be constructed for variations of major, critical-speed parameters over the entire range of the spring-constant ratios for pencil-shaped rotors, as well as for disks and intermediate shapes. Successive, major critical speeds are located at a constant spring-constant ratio on a given set of two, moment-of-inertia ratio curves.

A single two-branch curve that represents all rotor shapes applies at both extremities of foundation flexibility; floating and firm. With this curve to set the boundaries, only three calculations are required to define critical-speed solutions over the entire flexibility range.

Compared with a firm-foundation model, a flexible-foundation model introduces one additional bouncing-mode solution and two, additional conical-mode solutions. This analysis shows, however, that the critical speeds that the firm-foundation model does predict agree well with the corresponding flexible-foundation values.

This technique should aid in the preliminary design of turbomachinery by providing guidance to the location of potential synchronous and non-synchronous critical speeds and should be useful to manufacturers of electrical power-generating equipment.

Reference:

NASA-TN-D-4858 (N68-37214), Critical Speed Analysis of Rigid Rotors on Flexible Foundations,

Which may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $1.45)

Source: Richard H. Cavicchi
Lewis Research Center
(LEW-11061)

ANALYSIS AND OPTIMIZATION OF AN OMNIDIRECTIONAL DIRECTION-FINDING SYSTEM

The purpose of any radio direction-finding system is to obtain information from which the direction of arrival of an electromagnetic wave may be determined. Conventional systems for accomplishing this include null-seeking antennas having directional characteristics that are altered mechanically or electrically, highly directional antennas that can localize a region in space, and antennas composed of elements that use time- and space-phase displacement. These direction finders exhibit one or more of the following disadvantages: (1) they require mechanical positioning; (2) they present relatively large physical structures; and (3) the direction information is redundant or is not in a readily usable form. A direction-finding system which has been investigated analytically and experimentally does not have any of these disadvantages.

The direction of arrival of an electromagnetic wave above a plane earth may be uniquely described in terms of any of several space-coordinate systems. In particular, the knowledge of the direction cosines with respect to two perpendicular axes, both of which lie in the horizontal plane, is necessary and sufficient to describe completely this direction of arrival. Information in the explicit form of direction cosines (or direction-cosine analogs) is highly desirable in many applications. By means of simple analog circuitry, the information may be converted into that relating to other coordinate systems.

Although direction cosines appear as phase factors on the terminal voltages in linear arrays, there is difficulty in actually determining these direction cosines by phase measurement because of the unavoidable mutual impedances among the elements making up the array. By choosing an array with the proper spatial symmetry and by using signal-processing equipment, the undesirable mutual impedance effects may be eliminated from the system. Essentially, omnidirectional antenna elements are required to observe the hemisphere above a plane earth.

Certain components and characteristics of a theoretical system were analyzed and optimized, and the results were used to devise an experimental system capable of providing accurate direction information.

Source: E. R. Graf and J. M. Beste of
Auburn University
under contract to
Marshall Space Flight Center
(MFS-14346)

Circle 11 on Reader Service Card.

DEVELOPMENT OF A FIGURE OF RELIABILITY, MERIT ASSESSMENT TECHNIQUE

A method has been developed for assessing the reliability of design configurations, necessitated by insufficient, valid success/failure data. Configuration characteristics and operating conditions which affect the probability of success (trouble-free operation) are numerically evaluated and recorded on a format worksheet.

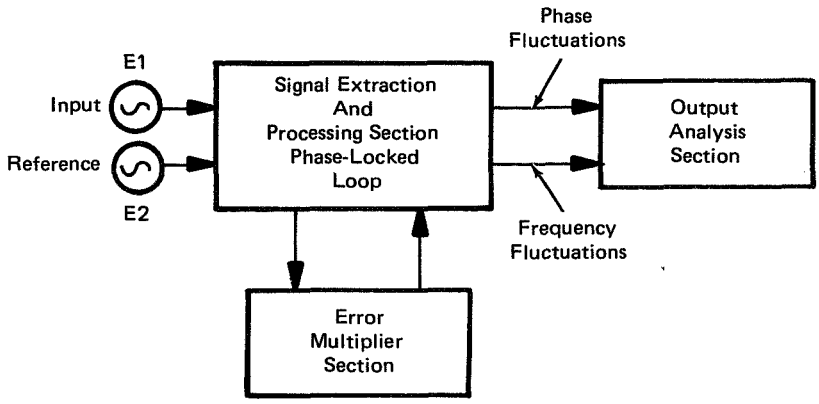
After this initial evaluation, a decision matrix rates each, the influence of each, and weights the total influence with a summation for the assessment of the configuration. This summation permits rapid comparison with other considered configurations and the subsequent selection of the optimum configuration from the reliability viewpoint.

The technique is essentially a conceptual-stage, comparison analysis tool, requiring no failure rate data or the time-consuming mathematical computations normally associated with numerical assessments.

Source: L. D. Backe and R. L. Peercy of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17369)

Circle 12 on Reader Service Card.

SPECTRAL ANALYSIS OF OSCILLATION INSTABILITIES IN FREQUENCY STANDARDS



Basic Configuration Of The Measurement System

The phase and frequency fluctuations inherent in oscillators used as frequency standards have been measured over the spectral frequency range of 1 Hz to 5 kHz. Experimental data for nine, commercially available oscillators were obtained with the oscillator instability analyzer shown in the figure. The basic measurement system consists of an electromechanical phase-locked loop that extracts the phase and frequency fluctuations and an error multiplier that extends the threshold sensitivity. Operational features include a selection of loop bandwidths, calibrated offset controls, and several output level selections.

The analysis of the data involves the application of the spectral density of the frequency or phase fluctuation as a function of spectral frequency. The format of the data, a spectral representation of the performance throughout the frequency, enables the designer to apply standard, circuit-and-system analysis techniques to determine the effects of various portions of the spectrum on the performance of the overall system.

Analysis of the experimental data has shown that the major, stability degrading mechanisms are flicker and thermal noise in both the oscillator feedback loop and the external circuits.

The instrumentation and mathematical analysis developed in this program can be used in the evaluation of such frequency standards as masers, crystal oscillators, and lasers, and in the development of low-noise snythesizers. The measurement techniques can be used for acceptance testing, design evaluation, and definition of performance specifications in terms of the phase angle and frequency spectral densities.

Source: S. Lippincott of
ADCOM Research and Development
under contract to
Marshall Space Flight Center
(MFS-20778)

Circle 13 on Reader Service Card.

RELIABILITY ANALYSIS BASED ON OPERATIONAL SUCCESS CRITERIA

The analysis of reliability is an important aspect of aerospace design, and a number of methods are currently employed to obtain estimates of the probable success of space missions. As a rule, the commonly-performed reliability analyses include: reliability estimates; failure-mode effects, and criticality analyses.

These analyses are usually performed independently at various stages of design development and do not result in quantitative visibility of design reliability as a function of design operation versus failure modes. The resulting reliability estimates, utilizing existing, reliability analysis methods, do not consider that certain failures are irrelevant to mission

success. Therefore, it was necessary to establish for a Jupiter mission a specific definition of mission success, so that the resulting reliability analysis would be a more accurate presentation of design reliability. The overall result was a more informed basis for making design decisions to optimize reliability. The techniques developed during a study of the reliability analysis for the Jupiter mission are applicable to any commercial design; and they can be extended into software of management systems as required, to identify probability of success or required corrective actions.

The baseline reliability prediction is the beginning point in the construction of a system reliability model. It is simply the calculation of overall system reliability based on the assumption that all elements are a reliability series; that is, any component failure is considered catastrophic to mission success. This, of course, is rarely true in any real-life situation, and thus the model predicts the system's true reliability to a first approximation only.

For a more accurate prediction of the system's true reliability, there needs to be an examination of a Failure Modes, Effects, and Criticality-Analysis Model, which disregards the failures of insignificant components. Certain assumptions are used to establish the baselines for the reliability prediction and the analytical method, among which are (1) constant failure rate as an exponential formula; (2) component type and quantity; (3) basic failure rates taken from actual experience with components; (4) no-failure rate for the critical component upon which the mission is predicated (e.g., an infrared detector); and (5) an experience factor for orbital reliability, (i.e., the ratio of the actual failures in orbit to the expected failures in orbit).

Source: F. G. Esmond and M. D. Johnson of
Santa Barbara Research Center
under contract to
Ames Research Center
(ARC-10490)

Circle 14 on Reader Service Card.

FUNDAMENTAL ELECTRODE KINETICS

For a complete understanding of the mechanism involved in any electrode reaction, it is necessary to study electrode kinetics, in order to determine the important rate-limiting steps in the overall electrode reaction.

A study was initiated, and a report has been prepared which presents the fundamentals of electrode kinetics and the methods used in evaluating the characteristic parameters of rapid-charge transfer processes at electrode-electrolyte interfaces. The modern concept of electrode kinetics is outlined, followed by a consideration of the theoretical principles underlying the experimental techniques for the sophisticated investigation of electrode kinetics.

Covered in the report are ohmic, mass-transfer and charge-transfer overpotential, and the determination of charge-transfer kinetic parameters. Also presented is the theory governing the following experimental techniques: voltametry, including both controlled-potential and controlled-current electrolysis; perturbation-relaxation techniques, including both potentiostatic and galvanostatic methods; and alternating-current methods.

An extensive list of basic references is contained in the report and should be useful to those interested in electroplating, electrolytic refining, and fuel cells.

Reference:
ANL-7072 (N66-33998) Electrode Kinetics
Which may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $1.45)

Source: J. P. Elder
Chemical Engineering Division
Argonne National Laboratory
(ARG-10067)

HEXAPOLE MAGNET FIELD ANALYSIS

The measurement of a hexapole magnet field using Hall-effect magnetometers or flip coils is inaccurate because their size is too large as compared to the magnet gap.

A method was developed in which the field of the hexapole magnet is analyzed by rotating the magnet about a wire loop of rectangular shape, placed inside the pole tips, and the induced loop voltage is measured with a wave analyzer. The quantitative characteristics of the field are then determined from this voltage, induced at various harmonics of the rotation frequency.

The technique requires an analyzer, a loop, and the magnet. The two components of the magnetic field are determined from the following expressions:

$$B_r = \Sigma B_n (r/r_o)^{n-1} \cos n\theta$$

$$B_\theta = -\Sigma B_n (r/r_o)^{n-1} \sin n\theta$$

where r_o is the radius of the magnet.

For a symmetric hexapole magnet, B_n has nonzero values at n = 3, 9, 15. . ., with n=3 producing the dominant term. The magnitude of B_n is determined by rotating the magnet about its axis and measuring the voltage induced in a rectangular pickup loop placed so that it is bisected by the magnet axis. In this arrangement, various harmonics of rotation frequency can readily be separated by the wave analyzer. Furthermore, the harmonic number of B_n can be unambiguously identified by measuring the rotation period with an electronic counter.

The voltage induced in the n'th harmonic is related to B_n by the expression:

$$V_n(t) = 2Lr_o \omega B_n (D/2r_o)^n \cos n\omega t$$

where L is the length of the loop, D its width measured between the centers of the wire, t is time, and ω is the angular frequency at which the magnet is rotated.

Applications of this technique are also useful in the design of hexapole magnets. For example, the effect of different pole-tip shapes on the field can be measured, and the effect of different designs on the maximum field strength can be determined.

Source: R. F. Lacey of
Hewlett-Packard Co.
under contract to
Goddard Space Flight Center
(GSC-10995)

Circle 15 on Reader Service Card.

A SYSTEM RELIABILITY ANALYSIS FOR STANDBY SPARES WITH NONZERO, UNPOWERED FAILURE RATES

Future space flights will require a spaceborne computer that is highly reliable and that can automatically switch in redundant hardware on a real time basis. This analysis was conducted to determine the best method of configuring such a system. A theoretical reliability analysis is performed for two different, standby system configurations, simulated by utilizing Monte Carlo techniques. The results agree within one percent of the theoretical reliability predictions. The two systems under consideration were the parallel standby configuration and a triple-redundant, majority-voting standby system.

The parallel standby system is characterized by having only one unit at a time powered up and all units possessing hardware error-detecting capabilities. In the majority-voting standby system, as long as there are at least three units, three of them will be powered up and the rest will be in an unpowered standby mode. When all but two of the units have failed, the voter can only tell when these final two units are not in agreement. Units do not have error-detecting hardware; however, software error detection may be introduced whenever the system is down to just two units and one of them fails.

Source: D. S. Taylor, J. E. Weatherbee, and
T. Williams of
Computer Sciences Corp.
under contract to
Marshall Space Flight Center
(MFS-22004)

Circle 16 on Reader Service Card.

EVALUATION OF JET ENGINE NOISE

In the modern designs of aircraft and space vehicles, it is necessary to determine the acoustic environment that will be generated by their propulsion systems. Jet noise, of course, is the main concern.

From the advanced theory for supersonic jet noise, there are three basic equations that characterize the jet noise environments. These equations are used to predict the magnitude of noise generation.

The three principal modes of jet-aircraft noise radiation include an acoustic mode and two Mach modes. The acoustic mode of radiation occurs for convection Mach (M_c) numbers below 0.8 and describes the sound power I(x) as

$$I(x) \sim \rho U^3 \frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2}\ 5/2$$

where ρ and U are the density and exit velocity of jet flow, respectively, M is the Mach number of the jet using ambient speed of sound as reference, M_c is the convection Mach number, θ is the angle between the wave propagation direction and the jet flow direction, and $\alpha^2 \approx 0.10$.

In the Mach modes, the sound power of the jet in the transonic and supersonic speed ranges are, respectively, given by

$$I(x) \sim \rho U^3 \frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2}$$

and

$$I(x) \sim \rho U^3 \frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2}\ 5/4$$

An extremely important effect established in this study is the coupled process of refraction and convection. In both the advanced and the conventional noise theories, the Doppler shift factor is defined as

$$f(\theta) = (1-M_c\cos\theta)^{-1}$$

As $M_c\cos\theta$ approaches unity, the Doppler shift factor produces both a large frequency shift and a large increase in noise intensity.

The effect of this factor has been a major disagreement between analysis and data; however, research has shown θ to be close to 90°. Hence, the magnitude of the convection factor is automatically limited to smaller values. Based upon this new theory, sound directivity spectra and intensities can be accurately predicted.

Source: S. P. Pao of
Wyle Laboratories
under contract to
Marshall Space Flight Center
(MFS-21416)

Circle 17 on Reader Service Card.

PREDICTION OF PERFORMANCE OF CENTRIFUGAL PUMPS DURING STARTS UNDER PRESSURE

Pressure-drop characteristics of centrifugal pumps during pressurized startup have been studied analytically, and a method for calculating startup characteristics has been developed.

In the development of chemical and nuclear rocket-engine systems, it is necessary to know system performance not only at the design point but also in a wide range of the off-design conditions. The need for this information is particularly crucial in the case of an engine system in which the hydraulic losses in the pump during startup affect the engine transient characteristics. Prediction of the off-design operation of these pumps is difficult because of the lack of information on hydraulic losses at the discharge of centrifugal impellers and at the entrance to the diffusers.

The method developed was based on the analysis both of work done on the pump's impeller and of the hydraulic losses within a pump when it is subjected to flow forced by a pressurized tank.

Calculations of startup characteristics were based on: (1) the pump geometry, including blade angles; (2) the design-point flow, speed, and pressure rise; and (3) the pump characteristics in a range within approximately 10 percent of the design-point flow.

Values were calculated for three pump configurations and compared with experimental data. Test data available for two pumps with vaned diffusers verified the analytical method quantitatively. In the third case, a pump with a vaneless diffuser, the procedure was verified qualitatively.

An empirical correction factor, based on an analytical extrapolation of the data from the pump's high-speed characteristic was used to adjust the analytical equations for the generally unknown losses due to the mismatch of flow and blade angles at the entrance of the diffuser.

The close agreement of calculated and experimental performance points verified the analytical method. The study demonstrated that it is possible to predict the pressure-drop characteristic of centrifugal pumps with vaned diffusers, provided the high-speed characteristic is known.

The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $1.45)
Reference: NASA TN-D-4967 (N69-14082), An Analytical Method for Predicting the Performance of Centrifugal Pumps During Pressurized Startup

Source: W. Rostafinski
Lewis Research Center
(LEW-10900)

CRYOGENIC PROOF TESTING

Proof testing titanium 6A1-4V alloy pressure vessels at cryogenic temperatures enables the confident prediction of higher, safe operating stresses and a longer fatigue life than would be possible after a proof test at room temperature. The notched tensile strength of this material decreases markedly as its temperature decreases. Thus, a successful proof test at cryogenic temperatures indicates that the vessel can safely withstand higher stresses when at room temperature.

This testing technique applies to other metals and alloys which exhibit the same temperature-versus-notched tensile strength relationship.

Source: R. A. Hilderman of
Grumman Aerospace Corp.
under contract to
Johnson Space Center
(MSC-12485)

Circle 18 on Reader Service Card.

DYNAMIC SIMULATION OF ENGINE THRUST LEVELS

The LM (Lunar Module) is equipped with a crushable, descent-engine nozzle extension designed to accommodate irregularities in the lunar surface without tilting the spacecraft. The failure mode of this extension, with the engine burning, could not be predicted accurately by analysis, and so a lunar landing simulation became a necessity.

The major problem was simulation of engine thrust levels to 25%, while maintaining a test chamber pressure which would not restrict normal expansion of combustion products. From prior scale-model testing, the CO_2 cryopumping capability of the space-simulation chamber, LN_2 shrouds was estimated at 7×10^6 liters/sec, which indicated that background pressures could be maintained in the micron range. Heating the CO_2, to obtain a better Gamma match and to avoid condensation during expansion, was provided by a pebble-bed heat exchanger consisting of stainless steel plates contained in a Hastelloy sheath. Surrounding the heat exchanger was a quartz array and reflector system capable of heating the core to a temperature in excess of 1200 K (1700° F).

In order to obtain the correct, material strength characteristics of the nozzle extension, a second quartz array was placed around the nozzle to provide a temperature profile compatible with the engine thrust level. Descent-to-lunar surface velocity was simulated by moving an aluminum plate at a predetermined velocity towards the engine. As this simulated lunar surface approached the nozzle extension, a cable and pulley system retracted the quartz array into a simulation of the descent-stage base heat shield, thus eliminating possible interference with the failure mode of the nozzle and permitting photographic coverage of the impaction.

Source: B. O. Bell and C. R. Walthers of
Grumman Aerospace Corp.
under contract to
Johnson Space Center.
(MSC-12496)

No further documentation is available.

Section 4. Structural Analysis

EVALUATION OF THE MODAL METHOD, THE STATISTICAL ENERGY-ANALYSIS METHOD, AND THE FOURIER TRANSFORM METHOD FOR STRUCTURES UNDER RANDOM ACOUSTIC EXCITATION

A report has been prepared that describes an evaluation program for three analytical methods used in the response analysis of plate-and-shell structures under random acoustic excitation. The methods evaluated are: (1) the statistical energy-analysis (SEA) method, (2) the modal method, and (3) the Fourier transform method. In order to determine the applicability and the limitations of the methods, the basic assumptions and the formulations of these methods are reviewed. Additional analytical derivations are performed in order to explore the problems involved in the basic formulations of the analyses. Based on the analytical and supporting experimental work, the workability and applicability of the methods are established. Some of the limitations and restrictions of the methods are postulated and described in detail.

In the report, a method to calculate the truncation error for plate-and-shallow shell structures has been formulated. An error analysis is performed involving the estimates of series residues corresponding to various structural configurations. The basic scheme of the computation makes use of the wave number presentation which has been applied by Courant, Bolotin, Wilkinson, and others in structural, modal density study. Using this approach, the truncation error of the modal method is established, at the resonance frequencies of the structure, as a function of the ratio of the resonance frequency to the cutoff frequency.

Source: C. Hwang of
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HONEYCOMB INTERNAL BURST PRESSURE PREDICTED BY PI-TENSION TESTING

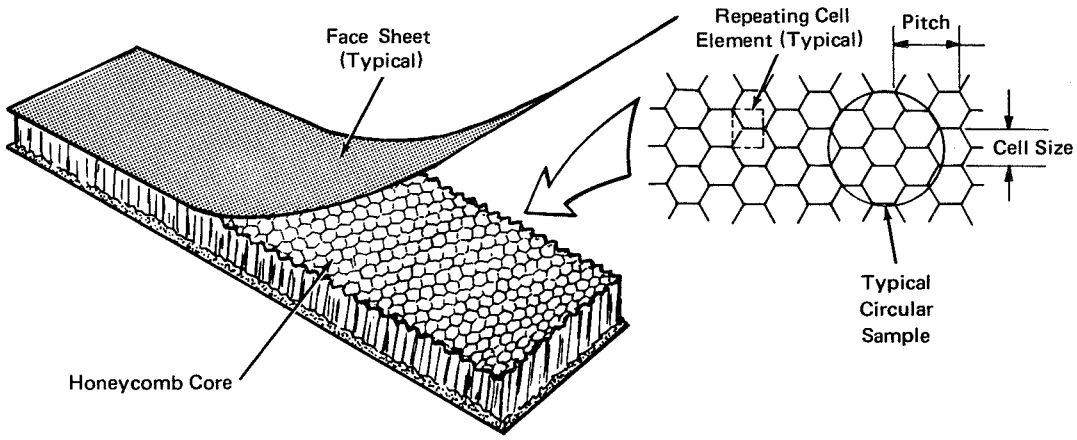

Figure 1. Normal Cell Size And Pitch

Existing analytical methods for predicting internal burst pressure between face sheets of honeycomb-sandwich constructed material, where bond or core separation occurs because of thermal/pressure conditions are inadequate. Costly and extensive test programs are required, and their application to specific support problems may be limited. A pi (flatwise) tension-testing technique already developed for honeycomb manufacturing-process control is used to determine the bursting pressure. The testing technique gives an analytical relationship to honeycomb, internal-burst pressure allowables. The pi-tension test technique uses a circular sample measured in pi-square inches of area directly loaded in the flatwise skin direction and internally loaded in the adhesive/core system.

Pi-tension and honeycomb, internal-burst pressure are dependent on the adhesive and the characteristics of the honeycomb core. In pi-tension testing, the rigid loading head insures that the load is evenly distributed over the core. Occasional void areas are masked due to the specimen size. However, honeycomb internal-burst pressures are affected by the presence of voids, because the internal pressures act locally on the adhesive of each cell. The figure shows normal cell size and pitch of a honeycomb cell. It is possible to use this data for development of a relationship between pi-tension testing results/requirements and honeycomb internal-burst pressure.

Source: R. D. Ferdie of
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Patent Information

The following innovations, described in this Compilation, have been patented or are being considered for patent action as indicated below:

Simple, Gas Chromatographic System for Analysis of Microbial Respiratory Gases (Page 2) ARC-10403

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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Nondispersive Infrared Analyzer for Specific Gases in Complex Mixtures (Page 4) ARC-10308

This invention has been patented by NASA (U.S. Patent No. 3,679,899). Inquiries concerning nonexclusive or exclusive license for its development should be addressed to:

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